Title:

Computer Modeling of Earthshine Contamination on the VIIRS Solar Diffuser

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Principle Author's Biography:

Stephen Mills is a Senior Engineer in the Sensors and Instrument Department at Northrop Grumman, Space Technology Division (NGST). He is currently assigned as the lead of sensor modeling processes within the Modeling and Simulation Team for the NPOESS program at NGST. He has worked for 25 years in the aerospace industry developing modeling and analyzing of optical systems.

Abstract Text:

The Visible/Infrared Imager Radiometer Suite (VIIRS), built by Raytheon Santa Barbara Remote Sensing (SBRS) will be one of the primary earth-observing remote-sensing instruments on the National Polar-Orbiting Operational Environmental Satellite System (NPOESS). It will also be installed on the NPOESS Preparatory Project (NPP). These satellite systems fly in a near-circular, sun-synchronous low-earth orbits at altitudes of approximately 830 km. VIIRS has 15 bands designed to measure reflectance with wavelengths between 412 nm and 2250 nm, and an additional 7 bands measuring primarily emissive radiance between 3700nm and 11450 nm.

The calibration source for the reflective bands is a solar diffuser (SD) that is illuminated once per orbit as the satellite passes from the dark side to the light side of the earth near the poles. Sunlight enters VIIRS through an opening in the front of the instrument. An attenuation screen covers the opening, but other than this there are no other optical elements between the SD and the sun. The BRDF of the SD and the transmittance of the attenuation screen is measured pre-flight, and so with knowledge of the angles of incidence, the radiance of the sun can be computed and is used as a reference to produce calibrated reflectances and radiances. Unfortunately, the opening also allows a significant amount of reflected earthshine to illuminate part of the SD, and this component introduces radiometric error to the calibration process. The VIIRS radiometric error budget allocated a 0.3% error based on modeling of the earthshine done by SBRS during the design phase. This model assumes that the earth has Lambertian BRDF with a maximum top-of-atmosphere albedo of 1.

The Moderate Resolution Imaging Spectroradiometer (MODIS) has an SD with a design similar to VIIRS, and in 2003 the MODIS Science Team reported to Northrop Grumman Space Technology (NGST), the prime contractor for NPOESS, their suspicion that earthshine contamination was causing higher than expected radiometric error, and asked whether VIIRS might have a similar problem. The NPOESS Models and Simulation (M&S) team considered whether the Lambertian BRDF assumption would cause an underestimating of the earthshine error. Particularly, snow, ice and water show very large BRDFs for geometries for forward scattered, near-grazing angles of incidence, and in common parlance this is called glare. The observed earth geometry during the period where the SD is illuminated by the sun has just such geometries that produce strongly forward scattering glare. In addition the SD acquisition occurs in the polar regions, where snow, ice and water are most prevalent. The M&S team produced a model that meticulously traced the light rays from the attenuation screen to each detector and combined this with a model of the satellite orbit, with solar geometry and radiative transfer models that include the effect of the BRDF of various surfaces. This modeling showed that radiometric errors up to 5% over water and 1.5% over snow or ice. Clouds produce errors up to 0.8%. The likelihood of these high errors has not yet been determined. Because of this analysis, various remedial options are being now considered.

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